
**Check Time Trends in
Growth Intercept Predictions
For Interior Spruce
Sampling Plan**

Prepared for

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1. INTRODUCTION

1.1 TERMS OF REFERENCE

This document outlines the sampling plan for the project "Check time trends in Growth Intercept predictions for interior spruce". In the first year of this two-year project, sampling was conducted in coastal Douglas-fir (Fdc) stands¹. In the second year, the project will focus on interior spruce (Sx). This sampling plan was prepared under contract to the Ministry of Forests (MOF) by Guillaume Thérien, *PhD* and A.Y. Omule, *PhD, RPF*. Our new project number is MFS-403-029, and the MOF contact person is Pat Martin, *RPF* (Forest Practices Branch).

1.2 BACKGROUND

For most commercial species in BC, site index in stands less than 30 years (breast-height age) is generally estimated through growth intercept (GI) equations. These GI equations were built from data collected in unmanaged, often fire-origin stands, and at least 50 years old (breast-height age). The GI equations, however, are generally applied to post-harvest regenerated (PHR) stands that have been planted and may have had brush and weed control.

There is a concern among foresters that early height growth rate in PHR stands might be different from the early height growth observed in older, unmanaged stands. Theoretically, site index should be independent of stand age. However, if there is a difference in early height growth between PHR and unmanaged stands, site index would be correlated with age. It is also plausible that a different early height growth rate may lead to a bias in site index estimation in PHR stands.

In 1998/1999, J.S. Thrower & Associates collected data to study the impact of using the GI equations in Fdc PHR stands. This study showed a correlation between site index and breast-height age below nine years. This study also showed that the Fdc GI equations could be biased if used outside the range of the data upon which they were built. In 1999/2000, the focus will be the GI equations for interior spruce, the second most important commercial species in BC.

1.3 OBJECTIVES

The objectives of this project are:

1. *To examine potential bias in Sx site index estimated using MOF GI equations.*
2. *To provide a case study for site index monitoring in young Sx stands.*

¹ J.S. Thrower & Associates Ltd. 1999. Trends in Growth Intercept Estimates of Fdc Site Index in Post-Harvest Regenerated Stands on Southern Vancouver Island. Unpublished Report to Min. Forests For. Practices Br., Victoria, Contract No. MFS-403-028. 11 p.

2. SAMPLING METHODS

2.1 POPULATION

To limit sampling costs, we restricted the study area to a small section of the geographic range of interior spruce². The study area includes 21 1:20,000 forest cover mapsheets around Prince George (mapsheets 093G084 to 093G090, 093G094 to 093G100, and 093J004 to 093J010). Only crown land within the Prince George Timber Supply Area (TSA) was included in the study area. The total area covered by these mapsheets is 306,832 ha, of which 177,773 ha (58%) are crown land (Table 1).

Table 1. Landbase breakdown.

Landbase	No Polygons	Area (ha)	Area (%)
Total Area	17,071	306,832	100%
Non-Crown Land	6,065	129,059	42.1%
Crown Land	11,006	177,773	57.9%
Non-spruce Leading	8,252	132,535	73.9%
Spruce Leading	2,754	45,238	26.1%
Outside Population	2,528	40,289	89.1%
Inside Population	226	4,949	10.9%
1969-1978 Stratum	145	3,828	77.3%
1979-1982 Stratum	81	1,121	22.7%

Spruce-leading stands represent 45,231 ha (26% of crown land). Sampling will be limited to a target population consisting of stands with the following attributes (according to the MOF inventory database):

1. First species is S or Sw;
2. Establishment year is between 1969 and 1982;
3. Spruce is the tallest and most important layer (layer=1, rank=1), and
4. Polygon is not labeled NSR (Not Sufficiently Restocked; non-forest descriptor is empty)

There are 226 stands meeting this definition, covering a total of 4,949 ha (11% of Sx-leading stands). It is possible that a number of these stands originated from the intermediate utilization (IU) partial cutting system used in balsam stands in the fifties and sixties. This information is not readily available in the MOF inventory database and must be verified in the field. Suspected IU stands will not be sampled. As well, fertilized polygons will be rejected. Polygons that had weeding, brushing, and juvenile spacing will be considered.

The target population will be stratified into two groups:

1. Stands established between 1979 and 1982, and

2. Stands established between 1968 and 1978.

The 1979-82 stratum covers 3,828 ha (77% of population) while the 1968-78 stratum covers 1,121 ha (23% of population). Stands from the younger stratum have a shorter history, and therefore less useful for studying GI biases, but are probably more representative of the current plantations of interest in which the GI equations are used. Stands from the older stratum are better suited for studying GI biases, but might be more similar in height growth patterns to natural stands (from which the GI equations were built). The proposed stratification will allow comparisons of height growth rates between the two strata.

2.2 SAMPLING DESIGN

2.2.1 Sample Size

A total of 26 polygons will be selected for sampling, 13 in each stratum. The expected productivity is one polygon/day, for a total of 26 field days.

2.2.2 Polygon and Random Point Selection

Sample polygons were systematically selected, proportional to area, with six random starts within each stratum from a list sorted by mapsheet and site index. A systematic sample from a sorted list tends to be more representative of the population than a random sample. The selection process is repeated six times with a different random start. In each selection run, one sixth of the sample size is selected. At the end, the six lists are grouped together to form the final sample list. Using multiple random starts with sequential sampling makes the variance estimation (based on random sampling theory) more accurate.

There is a high likelihood that some polygons in the target population will not be suitable for sampling because of a wrong age class, stand treatment, etc. To make sure we sample 13 polygons in each stratum, we created two sample lists: a list of target polygons, and a list of spare polygons (Appendix I). Each polygon in the list of target polygons will be visited. If a polygon is not suitable for sampling after field verification, it will be replaced by the first polygon in the spare list. If more than one polygon needs to be replaced, additional spare polygons will be chosen in sequential order from the list. The list of spare polygons was randomized to avoid any bias in selecting polygons in sequential order.

Since the 1979-82 stratum is smaller in area than the 1968-78 stratum, clusters from the 1979-82 stratum carry a bigger selection weight (SELWGT). The SELWGT for the two strata are:

²An exhaustive study covering a larger area could not be conducted due to funding limitations. Therefore, this project must be considered exploratory, a first step towards a more formal future investigation.

$$\text{SELWGT}_{1969-78} = \frac{3,828 \text{ ha}}{13} = 294.46$$

$$\text{SELWGT}_{1979-82} = \frac{1,121 \text{ ha}}{13} = 86.23$$

The selection weight will only be needed when comparing height growth and site index between strata.

The actual population of interest is the landbase that supports site trees (as defined in section 2.3.2). However, it is impossible to identify in advance this portion of the target population. Therefore, two random points were selected within a polygon: a principal point and a spare point. The spare point will be used in case the principal point generates an empty cluster (that is, it falls in an area that does not support site trees). An empty cluster is a cluster with no site trees. If both the principal and the spare points generate empty clusters, the crew will select a new polygon from the list of extra polygons, and include it in the list of target sample polygons. The crew will record if the sample is located at the principal or spare point.

2.2.3 Cluster Design

A five-plot, star-shaped cluster will be established at the selected point (Figure 1). One plot will be established at the random point, and the other four plots will be established 25 metres from the random point in the cardinal directions (North, East, South, and West). The plots will be 100-m² (5.64-m radius). Plots falling outside the polygon boundary will not be established. Each cluster will be weighted proportionally to the number of non-empty plots³. That is, the cluster weight (CLSWGt) is:

$$\text{CLSWGt} = \text{number of non - empty plots}$$

³ A non-empty plot is a plot with at least one site tree.

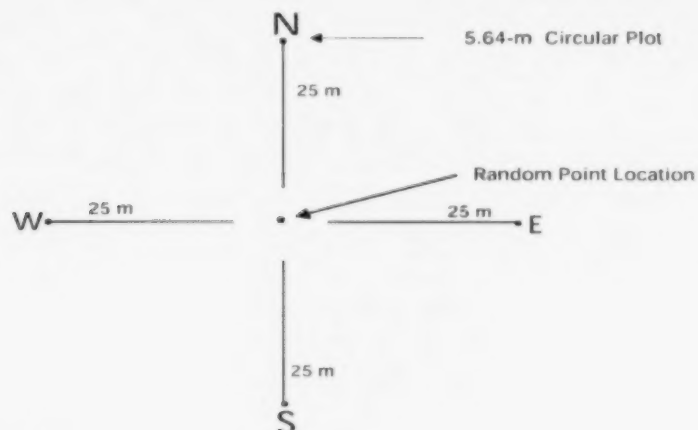


Figure 1. Cluster design.

2.3 FIELD MEASUREMENTS

2.3.1 Cluster and Plot Measurements

Biogeoclimatic zone, subzone, and variant, elevation, slope, and aspect will be recorded for the cluster at the random point location. The number of trees/ha and brush cover percent will be recorded on each individual plot.

2.3.2 Site Tree Selection and Measurements

In each plot, a spruce site tree meeting the following criteria will be selected:

1. The largest diameter at breast-height (DBH) spruce tree;
2. At least five years of growth above breast height;
3. Not advanced regeneration;
4. Undamaged, and
5. Free of early suppression.

No substitution of site trees is allowed in order to conform to the most recent top height definition. To be a valid observation, a cluster must have at least one site tree.

Site trees will be destructively sampled. The following attributes will be recorded:

1. Distance and bearing from plot center;
2. DBH;
3. Total height;
4. Crown class, and
5. the height of all annual nodes from a height of 30 cm up to 15 years above breast height.

A core or a disk will be taken at breast height to confirm breast-height age. Radial increment for the first 5, 10, and 15 years at breast height will be recorded. Whenever the crew is unsure of the age count based on annual nodes, a disk will be taken to confirm the age.

3. STATISTICAL METHODS

3.1 WEIGHTING

Each cluster represents one independent observation. Each observation will be weighted proportional to its selection weight (SELWGT) and its cluster weight (CLSWGT). The selection weight (based on population area) must be corrected to account for the proportion of the landbase that does not support appropriate site trees. This proportion is unknown, but can be estimated from the number of empty clusters that were found in each stratum. The area weight (AREAWGT) is therefore the stratum area multiplied by the proportion of non-empty clusters

$$\text{AREAWGT} = \text{AREA} \times \frac{\text{non - empty clusters}}{13}$$

The final weight (WGT) is the product of the selection, the area, and the cluster weights:

$$\text{WGT} = \text{SELWGT} \times \text{AREAWGT} \times \text{CLSWGT}$$

3.2 ANALYSIS

The analysis will include graphical and statistical analysis to test the following hypotheses:

1. Site index is constant over time at the cluster level.
2. Site index is constant over age at the cluster level.
3. The average height growth rate in stands from the 1969-78 stratum is similar to the average height growth rate in stands from the 1979-82 stratum.
4. In stands from the 1969-78 stratum, there is no difference between site index at earlier ages and the "true" site index (as defined by today's site index).

The analysis will also look at possible sources of bias, if any, through post-stratification (e.g., by elevation).

4. APPENDIX I - LIST OF SAMPLE POLYGONS

Table 2. List of sample polygons.

Cluster No	Mapsheet	Polygon	SI	Cluster No	Mapsheet	Polygon	SI
A-01	093G100	524	15	B-01	093G090	298	19
A-02	093J010	125	15	B-02	093G090	519	15
A-03	093G090	496	19	B-03	093J010	98	15
A-04	093G090	215	15	B-04	093G090	298	19
A-05	093G090	432	15	B-05	093G090	1004	19
A-06	093G100	208	15	B-06	093G090	325	15
A-07	093G100	475	15	B-07	093G090	912	19
A-08	093G100	512	19	B-08	093G090	295	19
A-09	093G090	647	15	B-09	093G100	573	19
A-10	093G100	634	19	B-10	093G094	578	19
A-11	093G090	619	19	B-11	093G100	698	15
A-12	093G100	208	15	B-12	093G100	916	19
A-13	093G100	808	15	B-13	093J010	98	15
Spare Polygons				Spare Polygons			
A-14	093G090	467	19	B-14	093G090	376	19
A-15	093G100	512	19	B-15	093G090	826	15
A-16	093J009	502	15	B-16	093J010	98	15
A-17	093G100	208	15	B-17	093G090	152	15
A-18	093G090	319	15	B-18	093G090	1003	19
A-19	093G100	650	19	B-19	093J010	98	15
A-20	093G089	417	19	B-20	093G090	1003	19
A-21	093G090	317	15	B-21	093G100	916	19
A-22	093G100	468	15	B-22	093G090	731	19
A-23	093G089	417	19	B-23	093G090	624	15
A-24	093G100	634	19	B-24	093G090	1003	19
A-25	093G100	958	15	B-25	093G090	624	15
A-26	093G100	201	15	B-26	093G100	90	15
A-27	093J010	414	15	B-27	093G100	533	15
A-28	093G090	274	15	B-28	093G090	298	19
A-29	093G090	597	19	B-29	093G090	554	19
A-30	093G100	579	19	B-30	093G090	826	15
A-31	093G094	589	15	B-31	093G090	152	15
A-32	093G099	387	19	B-32	093G100	531	15
A-33	093G100	797	15	B-33	093G100	706	15
A-34	093G090	647	15	B-34	093G100	995	19
A-35	093G100	711	19	B-35	093G094	635	15
A-36	093G099	387	19	B-36	093G090	420	15
A-37	093G090	466	19	B-37	093G100	698	15
A-38	093G090	466	19	B-38	093G090	420	15
A-39	093G100	208	15	B-39	093G100	533	15
A-40	093G090	466	19	B-40	093G100	706	15
A-41	093G100	206	15	B-41	093G090	325	15
A-42	093J009	502	15	B-42	093G090	624	15
A-43	093G100	714	15	B-43	093G100	990	15
A-44	093G100	475	15	B-44	093G100	533	15
A-45	093J009	508	15	B-45	093G090	152	15
A-46	093G100	784	15	B-46	093G090	515	15
A-47	093G100	201	15	B-47	093J010	98	15
A-48	093G099	277	15	B-48	093G100	533	15
A-49	093G100	956	15	B-49	093G090	110	15
A-50	093G100	208	15	B-50	093G100	995	19

Note: Plot number starting with A indicates a sample polygon from the 1969-78 stratum. Plot number starting with B indicates a sample polygon from the 1979-82 stratum.

